REVISED DRAFT MEMO

January 26, 2011

To: Phil Isenberg, Chair, Delta Stewardship Council
Members of the Delta Stewardship Council

From: Delta Independent Science Board

Re: Addressing multiple stressors and multiple goals in The Delta Plan

On August 18, 2010, some members of the California Legislature wrote to you requesting that the Delta Science Program (DSP) and the Delta Independent Science Board (DISB) "...conduct an assessment of stressors on populations of native fish species in the Delta, the Sacramento and San Joaquin rivers, and the tributaries to those rivers below the rim dams of the central valley." In your response dated September 15, 2010, you stated, "It is my intent to ask our science team, including the Independent Science Board, to develop a list of 'stressors' to the Delta, and then prioritize the stressors."

Given the apparent urgency around developing an approach to multiple stressors for the Delta Plan, the DISB notes and advises:

1. <u>There is no broadly agreed upon methodology for prioritizing multiple stressors.</u> Lacking established methods, the Council's decisions will necessarily blend scientific and political judgment.

2. <u>Stressors are linked to management objectives</u>. The importance of stressors depends on the value society places on different outcomes. The Council needs to be sure that each stressor addressed in the Delta plan is causally connected to desired aspects of the Delta ecosystem or water supply. Sound science and improved modeling can assure causal connection.

3. <u>Pay attention to the big, long-term drivers that generate particular stressors.</u> Climate change, population, and pollution are driving the numerous particular stressors causing serial change in the Delta ecosystem. These drivers need to be the focus of the long-term Delta plan.

4. Some of these drivers and their associated stressors cannot be mitigated and the main planning response must be adaptation.

5. <u>Support greater integration of Delta science</u>. The Delta Science Program and its prior efforts under CALFED provide the primary journal, conference venue, research support, and shared modeling efforts integrating Delta science. The DRERIP models provide the most relevant set of scientific tools for assessing the significance of different stressors, but DRERIP and complementary efforts need sustained support to prioritize stressors for future management.

Elaboration

The implementing legislation for the Delta Stewardship Council and Delta Plan, SBX7-1, specifies in Section 83502(c) that: "The Delta Plan shall include measures that promote all of the following characteristics of a healthy ecosystem" including (4) "reduced threats and stresses on the Delta ecosystem." Thus threats and stressors and their reduction must be addressed in The Delta Plan.

Members of the DISB, with assistance from the DSP, reviewed the approaches used for classifying and prioritizing stressors in a wide variety of environmental planning and management efforts in the United States and around the world. A list of key stressors was also developed (attachment 1). Then the DSP and DISB organized a workshop held in Sacramento on January 12, 2011 at which invited experts, members of DISB and the science program Lead Scientist addressed two questions: 1) Is it feasible to classify stressors in terms of their importance to the goals of Delta management; and 2) What methods could be used to accomplish that classification. The workshop also helped the Board assess the available science for use in Delta planning and recommend sustaining the science for future needs.

We elaborate on the key points of our discussion about multiple stressors and best available science as follows:

1. *There is no broadly agreed upon methodology for classifying and prioritizing multiple stressors.*

In the collective experience of the DISB the issues of multiple stressors and multiple objectives are pervasive, are of considerable concern to scientists, and are still being evaluated in the Delta, as they are for ecosystem planning and management worldwide. For a variety of reasons noted below, the ranking of stressors is especially difficult. Nonetheless, the Board finds that there are several approaches that can be used to assist in classifying and prioritizing stressors. These are discussed further in the following sections.

2. *The importance of a stressor depends on the importance of the management objective it impedes.*

The Delta Reform Act of 2009 specifies four basic goals for the Delta (section 29702) and further identifies a number of subgoals and characteristics of the Delta ecosystem and reliable water supply that the Delta Plan shall address (section 85302). These goals, subgoals and characteristics suggest an integrated set of objectives that the Delta plan must try to address. Stressors can be considered as variables or aspects of the Delta system that are obstacles to meeting the objectives. Thus, stressors and objectives are tightly linked in the sense that objectives define the important stressors and stressors affect the difficulty, or even possibility, of reaching the objectives.

Because of this tight linkage between policy and management objectives and stressors, the relative importance of stressors cannot be assessed, or prioritized, independent of the relative importance of the objective that is stressed. Scientists rarely address the relative values of different social objectives explicitly, and so consequently the scientific literature provides little information about the relative importance of stressors.

3. *Assessing, or ranking, stressors is very complex for many reasons.*

For example:

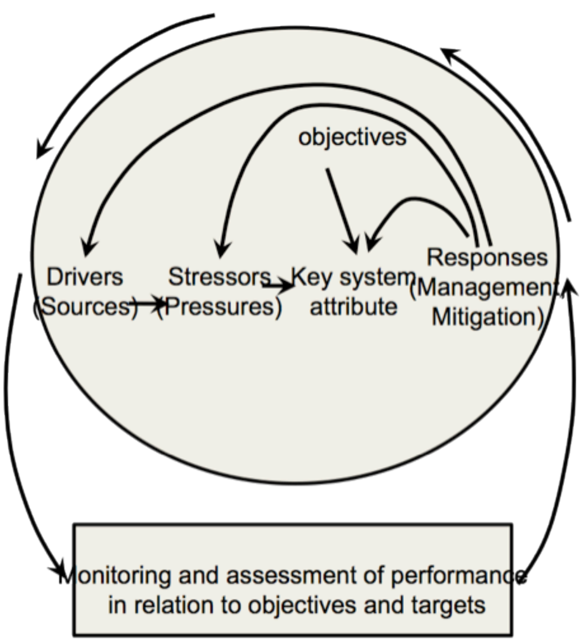
a) Multiple stressors typically affect an objective in complex, interactive ways that can make it very difficult to ascertain that one stressor is more important than another.
b) Objectives can also be interconnected.
c) A stressor that impedes reaching one objective may have positive effects on achieving another objective.
d) The action and importance of a stressor can vary over seasons or from year to year, or from place to place.
e) Objectives and stressors vary in importance, for example, as they are assessed at different spatial and temporal scales.
f) There are two broad categories of stressors, those that can be mitigated and those to which the Delta Plan must adapt, and prioritizing across these categories is probably counterproductive.

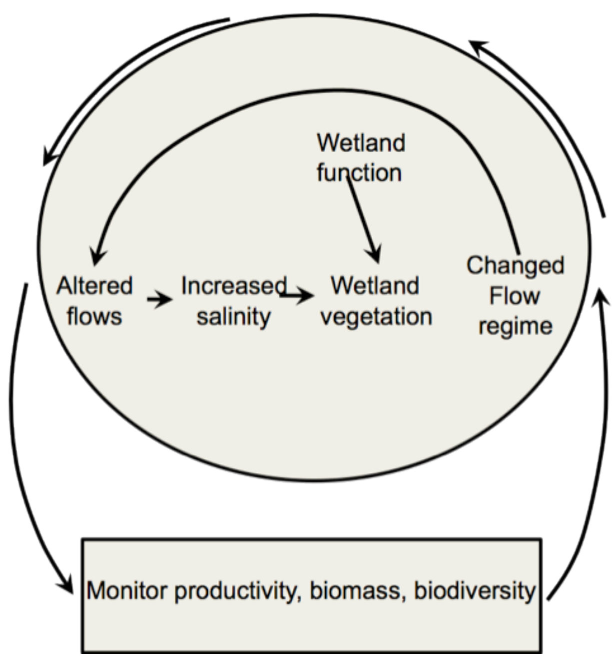
In developing the Delta Plan it will be important for the Council to look closely at the relationship between stressors and objectives to ensure that the most important stressors are identified and addressed in the plan. At the same time, for the reasons noted in a-f above, this will be a difficult part of the task that will require interactive scientific and political judgment.

4. *The terminology and ecosystem models used by different agencies and investigators in describing and classifying stressors are not standardized.*

Different reports and publications use different terms to refer to variables that have a negative effect on objectives or key system components. Driver, pressure, stressor, threat, are terms commonly used. What is at issue is the best way to capture cause-and-effect relationships between variables in the environment (stressors) and desired characteristics or products from the system (objectives). Variables and relationships have been conceptualized in different ways. For example, the European Environment Agency has adopted an approach with the acronym DPSIR (Driver, Pressure, State, Impact, Response). This approach distinguishes between Drivers, or the source of variables causally linked to objectives, and pressures, or the variables that directly effect objectives (see: http://enviro.lclark.edu:8002/rid=1145949501662_742777852_522/DPSIR%20Overview.pdf). In contrast, the DRERIP (Delta Regional Ecosystem Restoration Implementation Plan) adopted a Driver, Linkage, Outcome terminology to capture the causal linkages between environmental variables and key system components or objectives (see: http://www.dfg.ca.gov/delta/erpdeltaplan/). The DRERIP terminology and approach underpins recent work by the Pelagic Organism Decline team (see; http://calwater.ca.gov/science/pod/pod_index.html) and the Bay Delta Conservation Plan (see: http://baydeltaconservationplan.com/Home.aspx). Another useful set of tools is contained in the US EPA CADDIS (Causal Analysis/Diagnosis Decision Information System: http://www.epa.gov/caddis/), which uses a "source, stressor, outcome" sequence to identify and evaluate stressors. Each of these approaches has different strengths and weaknesses. It is important to recognize, however, that the different approaches and terminologies are conceptually rather similar. Mainly they differ in the degree to which they may aggregate causal factors and in the labels they apply to different aspects of the system linking causes to outcomes. It can be important to distinguish between what is stressing a system attribute (e.g., a species population, water quality) and what is producing, or driving, the stress, because this could affect the likelihood of successfully realizing goals and objectives. However, management actions can target different levels in the chain of causation depending on circumstances.

The DISB believes that defining and delineating stressors is best accomplished by developing a conceptual model that clearly specifies the relationships between cause and effect with respect to the attributes of interest. Such models have been successfully used as a template for structuring an ecosystem-management approach in numerous regional assessments. For example, they have been used as a basis for management programs in the Everglades of south Florida (Gentile et al. 2001) and Alaska (Harwell et al. 2010) and are the foundation of conservation planning in The Nature Conservancy (see http://conserveonline.org/workspaces/cbdgateway/cap/index_html) and the Conservation Measures Partnership (see http://www.conservationmeasures.org/). In these programs, the conceptual models have been used to identify risks and develop performance criteria as well as to provide a clear understanding of stressors in the systems. Conceptual models also are a prominent part of DRERIP including both species life history models and ecosystem component models. Because they are specific to the Delta, the DRERIP models provide a valuable resource for characterizing causal linkages between stressors and objectives and for prioritizing stressors. The following diagrams illustrate (on the left) how DRERIP conceptualizes the pathways linking Drivers to outcomes and objectives and how stressors fit into this causal chain and (on the right) provide a hypothetical example to clarify the components and linkages of this conceptualization.





This conceptual model is derived from the DPSIR approach and generally follows the approach of Gentile et al. (2001). The DRERIP models, in general, represent the left 3 steps within the large oval (Drivers, Stressors, Key ecosystem attribute, which in DRERIP terms are Drivers, Linkages, Outcomes). In the model above:

- *Drivers* are the sources or creators of stress that exert pressure on the ecosystem; in our example, altered flows.
- *Pressures* are the *stressors*, the factors that act to determine the condition of a system attribute of interest; in our example, increased salinity is one of many consequences of altered flow.
- *Key system attributes* are the components of the system that are of interest or concern; for example the condition (e.g. physiology, reproduction, productivity) of wetland vegetation. Other examples of key system attributes might include the specific life-history stage of a species that is affected by a particular stressor or the population size of a listed species.
- *Responses* are the actions that are taken to maintain or improve the condition of key system attributes; in our example, this would be changing the flow regime to reduce salinity stress at critical times of the year. Responses can be directed at the drivers or the stressors, to remove or mitigate their effects, or at the key system attributes, to facilitate adaptation to the stressors. In our example, the management is directed at the driver; other management actions could be directed at the wetland vegetation (e.g., protecting critical areas or vegetation restoration), but management directed at the stressor itself (salinity) is less likely.
- *Objectives* describe preferred outcomes of management actions on key system attributes; in this example, restoring or improving wetland functioning.
- *Performance measures* are metrics describing the state of key system attributes that can be used to assess progress in meeting objectives; in our example, progress might be evaluated by monitoring measures of productivity, biomass, or biodiversity.
- All elements of this conceptualization -- the linkages among drivers, stressors, key system attributes, responses, objectives, and performance measures -- are parts of an ongoing, dynamic process of *adaptive management*.

Understanding how particular factors fit into this conceptualization – as drivers, stressors, or key system attributes – and developing scientifically sound conceptual models of the causal relationships - is critical because it affects where management actions can be most effective and what to expect (and monitor) as a result of the actions. In general, actions directed at a driver (e.g., water flow) will affect multiple stressors (e.g., water temperature, seasonality, chemistry, as well as salinity), whereas actions directed at stressors will have more targeted effects. Importantly, **a stressor should be defined in terms of its effect on a key system attribute and an objective for that attribute**. In the above example, increased salinity may be a widespread or frequent consequence of altered flows, but it will differ in its effects (i.e., its status as a stressor) on different species or system components. Furthermore, there are temporal and spatial dimensions to the presence of a stressor; salinity levels may vary seasonally and be dependent on location in the Bay-Delta system. Finally, stressors are scale-dependent – some stressors may act broadly, others only in localized situations. Proper assessment of stressors requires consideration of temporal and spatial variation and the operating scales at which drivers are linked to stressors and attributes. Management actions need to be commensurate with the scale of the stressor.

5. *Different kinds of stressors call for different kinds of responses*

Stressors can be classified in various ways; in terms of origin, mode of action, spatial and temporal breadth of impact, whether or not managers have the ability to affect their action, and so on. Classifying stressors is an essential step toward understanding, and eventually to assessing, them. The DISB found the following four categories of stressors to be helpful in our own discussions of the Delta:

1) Globally determined stressors—stressors, like the effects of climate change or population growth, which cannot be eliminated or mitigated within the purview of the Delta Plan. Management actions must adapt to the continued effects of these stressors in the Delta.
2) Legacy stressors—stressors that result from past actions in the Delta watershed that cannot be undone. These include stressors such as the continuing effects of sediment and mercury discharge during the gold mining era. Infrastructure that causes stress on the Delta and is not likely to be significantly altered, such as upstream dams and the network of levees, can also be treated as legacy stressors. Although these stressors cannot be eliminated, management actions can reduce their effects on the Delta.
3) Anticipated stressors—stressors that scientists can anticipate will result from present or future activities. The Delta Plan can modify these stressors in such a way as to prevent or reduce the stressor or better adapt to the stressor.
4) Current stressors—stressors that result from ongoing activities, such as water management practices, agricultural practices, waste discharges, etc. Management actions can either change those practices, take steps to reduce their effects-on the Delta, or both.

Note that the legacy stressors exist because of an historic failure by Californians to anticipate and prevent or mitigate the long-term effects of human activity. They serve as a good reminder to us of the importance of anticipating stressors and reducing them through planning.

We list “current stressors” last because The Delta Plan needs to take the long temporal view. To the extent that current stressors are expected to carry on into the future, including how water is managed, the DSC should address them.

In preparing for the workshop on January 12, the DISB compiled a list of stressors affecting the Delta. These are organized in relation to the categories above in attachment 1 to this memo. The list of stressors is not comprehensive, nor has it as yet been vetted in terms of how the various stressors relate to the objectives, sub-objectives and characteristics listed in SBX7-1. However, the list serves to illustrate the broad range of kinds of stressors that must be considered in developing the Delta Plan and some of the constraints on opportunities to mitigate their effects.

Some long-term stressors, such as sea level rise, cannot be mitigated and must be adapted to. In some cases, when confronted with such stressors, objectives will have to be modified to fit the reality of the stressor. In other cases, the objective might be reached, or partially reached, through adaptation, for example, by improving levees. Where adaptation is necessary, the stressor requires us to reconsider the objective.

Where mitigation is possible, specific objectives are needed simply to identify what the stressors are. For example, section 83502(c)(1) specifies the objective of having “viable populations of native resident and migratory species.” To determine which stressors are preventing viable populations of native species, one typically must look at particular species – Chinook Salmon, Black Brant, etc. – and what has been stressing them. In the process of identifying stressors, one might logically overlook less valued species or less valued states of the environment except to the extent they are important to valued species or valued states of the environment. That is to say, a focus on particular species (listed species, for example) may lead to management measures that are detrimental to other species. Thus, even where a stressor can be mitigated, the outcome may not be universally positive. Trade-offs will be necessary as will vigilance in assessing the broad consequences of stressor reduction.

5. Pay attention to the big, long-term stressors

Decision-makers need to be aware of the serial changes that are occurring in the delta as well as the potential for catastrophic change if delta levees fail. Assessment of stressors and their prioritization must be undertaken in the context of this continual change over time. Consequently decision-makers need to be looking 30-50 years into the future as they develop policy. Experience has shown that the development and implementation of major policies can take more than a decade and response times to policy change are also on the order of a decade or more. In essence, policies to manage for the coequal goals will need to be flexible and nimble enough to succeed in the context of continual and uncertain change.

The delta is a system in which serial change in important variables is having a large impact on the coequal goals. For example, several key variables are being affected by climate change. Although total precipitation is not changing much, less is falling as snow so that the winter snow pack is decreasing. Because the snow pack is the major storehouse of water for spring and summer irrigation, loss of snow pack strongly affects the amount of water that is available for human uses. With warming temperatures, snow pack is melting earlier and winter flows are less stable. Consequently, peak flows occur earlier and over a shorter period of time. Air temperatures are also increasing so that both patterns of inflow to the delta and water temperature are changing over time. Rising sea level is changing the salinity of the delta and also increasing the risk to delta levees. In addition to changes resulting from climate change, the likelihood of an earthquake within this century that will cause catastrophic breaks in delta levees is high. Thus there is significant risk that a number of delta islands may be flooded in the future. Economic considerations will influence any decision about restoration of the levees, so that the future delta may include a number of flooded islands as large deep lakes. Such flooding of islands will have important implications for the hydrodynamics and salinity of the Delta, will affect the quality of water exported from the Delta, and will impact Delta land use. New species continue to be introduced to the delta so scientists expect that the biological community will continue to change with uncertain implications for native species. These kinds of broad scale changes will also affect terrestrial ecosystems; changing habitat conditions for plants and wildlife, particularly migratory birds. Exotic species are also invading terrestrial habitats, with effects on productivity and food webs for native species. Processes of continual change also derive from population growth, urban expansion, agricultural practice and a host of other human activities in and around the delta.

These continual processes of change greatly complicate development of effective management policy to protect, restore and enhance the delta. Indeed, some analysts suggest that the delta has entered a new ecological regime significantly different from its historic regime or even the recent past. This may not be a stable regime but rather a transitory condition that will continue to change as climate change and other unmanageable stressors continue to change the Delta.

Serial change in the delta also has major implications for water use and water supply. Changing patterns of precipitation and declining snow packs will affect system operations and exacerbate some conflicts and trade-offs over water for human and ecosystem uses. There is a high likelihood of major levee failure, changing delta hydrodynamics, and increased salt penetration that will affect water quality and its usefulness for agriculture and domestic use. As changing climate increases stress on listed species, conservation may demand more water for environmental protection, further reducing the flows available for other uses.

6. Policies to deal with multiple stressors have highly uncertain consequences

Although the delta is a relatively well-studied environmental system, our ability to predict the Delta of the future is not strong. Scientific inferences are quite uncertain because the ongoing, serial change that is occurring in the delta makes future states difficult to predict. Relationships that appear relatively well developed at one point in time (e.g., the relationship between abundance of four species in the Pelagic Organism Decline, and X_2 (The distance upstream from Golden Gate of the isopleth of 2 practical salinity units)) tend to break down as additional years of data are accumulated. Another consequence of change and non-linear responses to stressors is that even in circumstances where there is a clear dose/response relationship between change in a stressor and response of the system in the past, removing the stressor may not result in a reversal of the observed dose response relationship. This may be because the system may be more or less responsive than was observed in the past. A consequence of this uncertainty is that simply relieving stressors may not lead to desired outcomes. This fact speaks strongly to the need to implement policy as adaptive management experiments in which there is a clearly developed process for gathering information on the effectiveness of the policy and a mechanism for review and updating of all aspects of the policy over time. This need includes problem definition, conceptual model, indicator variables, and policy response.

SB X7 defines adaptive management in section 85052. "Adaptive management" means a framework and flexible decision-making process for ongoing knowledge acquisition, monitoring, and evaluation leading to continuous improvement in management planning and implementation of a project to achieve specified objectives." This definition is a fairly standard one but assumes a system that is reasonably stable over time. The serial change that is occurring in the delta means that the adaptive approach must remain flexible but needs also to recognize that policies may fail not only because of uncertainty in system behavior but because the system is actually changing over time in fundamental ways. In practical terms this places more emphasis on the importance of the monitoring programs and timely analysis of the data generated as well as ongoing research in the delta to identify and anticipate the emergence of conditions that could undermine the effectiveness of policy.

7. *Support Delta science.*

The DISB is impressed with the variety and depth of past scientific efforts and on-going research in the Delta. The Delta Science Program plays a central role in communicating and coordinating Delta Science as well as funding critical scientific initiatives. But DISB is also concerned that Delta science needs stronger integration and standardization. In this sense, the DISB found the DRERIP terminology and approach to be an especially good start with considerable potential for further development. The DRERIP models provide an objective, science based set of tools for evaluating stressors. The set of models does not, as yet, cover all the aspects that are of concern to the Council and at present are static models that require staff to work out the effects of varying a stressor qualitatively. The usefulness of these models would be greatly enhanced if they were made dynamic and interactive. Support to accomplish this through the science program would give the science program and the Council a powerful, locally designed set of tools for assessing stressors now and in the future.

8. *Expect surprises*

As noted earlier, the delta is changing over time. Some changes, like the effects of changing hydrology and sea level rise due to climate change, can be anticipated and modeled. In addition to changing climate, the 21st-century Delta faces the likelihood of earthquakes that may leave a number for islands permanently flooded. Other changes are more contingent on unforeseeable circumstances, like species invasion or levee failure by decay. Regardless, uncertainty virtually guarantees that large, unexpected events will occur from time to time. From the perspective of analysis and prioritization of drivers and stressors this has several implications. First, scientists and managers need to be continually alert for the emergence of new drivers and stressors. Second, the governance process needs to be nimble enough to adjust policy and management to respond to emerging problems. Third, even if management is focused on a subset of stressors, monitoring should continue to gather information on a broad spectrum of stressors as a means to monitor the “pulse” of the delta.

All members of the DISB have approved the content of this memo. The DISB also proposes to prepare a more detailed report on stressor classification and prioritization to be submitted to the Delta Council by mid March.

Attachment 1

Table of Drivers and stressors in the Bay-Delta Ecosystems categorized by the kinds of actions that could be taken to reduce them. [Notes include both changes in state of the ecosystem as well as examples of impacts]

Type	Driver (D) or Stressor (S)	Notes
1	D Climate change	
	S Reduced inflow & outflow	Possibly lower water yield
	S Changed hydrograph	Altered seasonal patterns (earlier, smaller freshet)
	S Higher temperatures	Seasonal temperature variation; altered phenology (e.g., timing mismatch between predators & prey, flower and

		pollinator); species and biogeochemical processes impacted by temperature;
	S Sea level rise	Salinity intrusion, levee breaches, altered rates of erosion and deposition
	S Changing ocean conditions	Many Delta species spend part of their lives living or feeding in the ocean
	S Earthquakes	Levee and highway damage
	D Population growth	Places increasing pressure on land and water resources
	D California economy	Patterns of development, agriculture, recreation are driven by economics
2	S Habitat loss and alteration	Loss or reduction of seasonal and tidal wetlands, riparian habitats, gallery forests and native grasslands; simplified system of leveed agricultural islands separated by deep channels with leveed shorelines; small, unconnected fragments of natural habitat; channels unconnected to floodplain; uplands less connected to Delta; channels dredged, interconnected, and simplified; terrestrial diversity reduced; impacts include: changing competition and predation, loss of access to breeding sites
	S Changed pattern of flow	Channel simplification and interconnection changed flow velocity and pattern; infrequent floodplain inundation; impacts include: migration barriers, altered migration corridors, improved water conveyance to south Delta, salt entrainment affects domestic water supply, loss of access to breeding sites, greater tidal excursion and salt penetration into Delta
	S Methyl-mercury from released mercury	Changing Delta conditions can affect the methylation of mercury stored in sediments; impacts include mercury bioaccumulation in the foodweb
	S Selenium	Past practices resulting in residual toxins in the food web
	S Subsidence	Loss of peat soils in islands; impacts include increased risk of levee breaks with loss of structures and habitat
	S Changing sediment loads	Sediment delivery increased with European colonization and is now declining; impacts include: turbidity declines, altered erosion and deposition, SAV expansion, smelt distribution
	S Artificial levees	Isolated land and water ecosystems & made possible the development of the Delta's cultural & economic character
	S Water management infrastructure	Increases reliability of water delivery; habitat loss; altered migration corridors
	S Levee breaks	Permanent flooding of multiple W islands would likely raise salinity in the S Delta; native fish may not use deeply flooded islands
	S Upstream dams	Loss of access to breeding sites; existence and operation affect virtually every aspect of Delta environment, society and economy
	S Federal-state agricultural policies	Ag subsidies affect land use and habitation patterns

	S Development, zoning, building codes	Effects land use, lifestyle choices & many other human decisions affecting the Delta
	S Invasive species	Low prey; changed food web; changing competition; higher predation; agricultural pests
3	S Subsidence	Loss of peat soils in islands; impacts include increased risk of levee breaks with loss of structures and habitat
	S Landscape change	Delta's habitat mosaic is constantly changing as human land and water use evolves
	S Urban expansion	Affects the Delta in many ways that threaten native species and ecosystems, water quality and demand, unique Delta attributes
	S Upstream landuse	Affects the quantity and quality of water entering the Delta, sediment load, habitat for species migrating through Delta
	S Upstream dams	Existence and operation affect virtually every aspect of Delta environment, society and economy
	S Lifestyle choices	Decisions about where and how to live affect species, habitats, water demand
	S Urban-rural migration patterns	Dominant human migration pattersn are rural to urban and inland to coastal
	S Invasive species	low prey; changed food web; changing competition; higher predation;
4	S Changed hydrograph; reduced inflow and outflow	Upstream water withdrawals; water project and in-Delta withdrawals reduce flow through Delta; reduced seasonal flow variation; improved seasonal availability of water for agriculture; impacts include: salinity intrusion, less salinity variability, seasonal temperature changes, water residence time more uniform, stranding, low DO and thermal migration barriers
	S Entrainment at pumps & other diversions	Effect of OMR flows on fish movement and water supply; in-Delta withdrawals for agriculture, domestic water, power plants
	S More nitrate, ammonium and less phosphorus	Excess nutrients from agriculture and domestic waste; altered N/P ratios; impacts include: low DO, SAV expansion, *Microcystis* blooms, reduced phytoplankton production, can favor invasive species
	S Selenium release	Releases by agriculture and industry can be toxic through the food web
	S Pesticide release	Agriculture, industry, and residential use (pyrethroids & organophosphates of concern)
	S Other trace metals and toxics	Lead, chromium, copper, surfactants, endocrine mimics and disruptors introduced from agriculture, industry, domestic waste, and storm water
	S Dredging	Channel dredging mobilizes sediment & toxins; impacts benthic organisms
	S Legal harvest	Incidental take of threatened species

	S Illegal harvest	Illegal take of threatened species
	S Hatchery impacts	Alters genetic makeup affecting ability to perform in the wild & wild conspecifics with which they breed
	S Federal-state agricultural policy	Ag subsidies affect land use and habitation patterns
	S Development, zoning, building codes	Effects land use, lifestyle choices & many other human decisions affecting the Delta